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A Survey on Virtual Reality, Augmented Reality and Mixed Reality Techniques for Liver Surgical Operations and Training

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Abstract
This Paper presents a survey of recent trends in VR techniques with more focus on mixed reality from perspectives of liver surgical operations and training. It presents the challenges facing liver surgeons prior, during and after liver operations. Moreover, the promising gains in liver surgery due to the use of both AR and MR have been highlighted. Moreover, the gained support of MR has been evaluated in contrast to the addressed challenges facing liver surgeons. This paper serves as a phase one of experimental case study going on by researchers to propose an efficient while the more effective framework for enhancing liver surgical operation especially in the LDLT and hepatic resection by using MR techniques and tools.

Keywords: *Train Surgeons, LDLT, SPM, CT, VR, AR, MR.*

Nomenclature

LDLT	living donor liver Transplantation
SPM	Simulation Process Module
CT	Computerized Tomography Scanner
VR	Virtual Reality
AR	Augmented Reality
MR	Mixed Reality
Dicom	Digital Imaging and Communications in Medicine
3D	Three-dimensional
IT	Information Technology
EDA	Electrodermal Activity
DES	Differential Emotion Survey
PANAS	Positive Impact and Negative Affect Schedule
LSO	Liver Surgical Operation

1. Introduction
The reported successes Virtual Reality (VR) techniques and tools have gained remarkable interest by both research and professional communities and still paving roads for new application fields in many domains especially the medical domain. VR has enabled simulating reality whether to enhance designs or to analyze behavior in some unreachable applications and the reported success of a number of disciplines has even enabled using VR in many fields in real time. Terms such as virtual, augmented or mixed, have been coined as a result of continuous efforts by researchers and companies to and explore the changes we are making to the surrounding real environment. There has been a flood of developed tools by most related companies including the giant ones; for example, Samsung, Facebook, Google, Microsoft, and examples of companies that have devoted sections for developing and enhancing many hardware components such as sensors, transducers, computers while also providing supporting real-time software needed by the Virtual Environment (VE). Virtual Reality[1](VR) and Augmented Reality (AR) are key technologies of Virtual Prototyping as they enable easy user interface while also facilitate an interactive exploration of the functionality of a new including MR play a significant role in enhancing liver operations especially in the LDLT and hepatic resection.
Virtual reality is a technology that takes the user to a new reality that is not currently present through the glasses mostly and a surround sound system to enhance the experience as much as possible, for the best experience to use It, you can use glasses on a small screen. The system then divides the screen into two equal parts, displaying the same image to make the brain match to appear as a single image.
On the other hand, there has been a remarkable advance in the medical field's techniques and more pronounced is the surgical one. The recent surgical revolution has changed the way the surgeons begin their work. Technological advances, equipment, materials, robotics and computer systems and more pronounced the virtual reality technology [1, 2]. Virtual (VR) and Mixed Reality (MR) Technology while also address essential components enabling Virtual environment (VE) such as head mounted display systems, simulators and applications of surgery and techniques augmented reality in surgery and liver surgery and reality.
VR has gained a remarkable success in most medical fields especially in surgical applications, interactive medical training, and diagnostics of many symptoms of deceases. For instance, surgical planning has been one of

the most reported successes of VR in many cases especially in plastic surgery and liver diagnostics and operations. For instance, liver surgery has recently witnessed many developments and enhancements due to employing VR techniques [3]. The addressed interest of using VR for liver surgery has been stimulated by the horrible spread out of such scaring disease taking into account the unaccepted failure rate of many liver surgical operation results due to the ambiguity of the pre-diagnosis or pre-surgical planning. A challenging problem while training surgeons on liver resection before starting to practice surgery. Moreover, depending only on the getting radiation for each patient CT causes fear of surgeons of bleeding or cutting in one of the arteries or veins without specifying the right direction during the surgical procedure. For instance, in many different cases risks that may result from the operation due to the incomplete indicators supported by X-Ray and other techniques that stand unable to enable surgeons to form locating accurately the cutting and implantation of the liver. Moreover, such traditional techniques while still important wouldn't be enough to guide surgeons to the proper relationship and link of blood vessels and liver which are of critical importance to surgeons prior operations and while performing the liver surgery and initial to be planned to help the surgeon during operations to locate cutting and transplantation edges while also measuring the surrounding blood vessels through the total images of dicom as a result of a well-defined images of liver form. Accordingly, It becomes quite important if not a must, to provide assistance in a form of 3D data and information for each patient to enable surgeon/ trainee to gain complete insight into patient's liver prior, during and after an operation. The mixed reality technology has reported success in providing surgeons with such 3D information for each patient on touch screens so they can interact with the liver and take precautions for possible reactions without risking the patient's life during the actual treatment.

This paper is organized as follows: Section2. Overview and technical analysis between virtual augmented and mixed reality technology. Section3. Visualization techniques rates and indicators by Google trend. Section 4 and 5. Augmented and Virtual reality techniques in liver surgery. Section6. Challenges of Liver Surgical Operations. Section7. Visualization of Liver Surgical Operation Techniques (flowchart & pseudo code). Section8. Summary and Conclusions.

2. Virtual, Mixed and Augmented Reality (V, M&AR) Technology, an Overview

The use of virtual reality technology in the formation of theatrical cinema through narration with the theory of virtual reality concept and its basic features, its evolution and its uses in theatrical presentation and the principles of design elements of the scene using computer programs such as 3Ds Max, for some theatrical performances using the latest virtual reality techniques through ship design and characters Models and animations But there is a clear problem of not interacting directly with the audience (Force FeedBack), using specific models designed according to the scenario in particular. [4] the augmented reality applications, position, direction, positioning, and tracking are calculated as appropriate to the user. Trace can be divided into two tracking types of sensors and vision tracking, and the existing vision tracking is classified into two sections based on markers placed to determine stereoscopic capture and tracking within a three-dimensional stereoscopic scene to capture and monitor the movement used For individuals and their installation in 3D models, either the second section is tracked based on the signs found between the images of the real elements at the scene and their known 3D locations in the real world[5], The system sends two images to the same scene of the brain to match and here the user feels like there, that is, the situation in the reality of the virtual and cannot move through the movement of the head only, with the presence of some simple devices that contribute to the input process, and emerged some models that allow the user to move forward and backward To reveal more details, models that are never hindered by anything, technology is easy to develop, but the portrayal of this type of clips is certainly the most important. Follow Figure1.

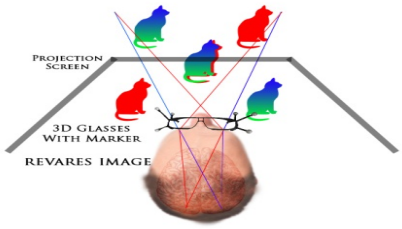

Figure 1. VR-3D Glasses with marker [6]

Augmented Reality(AR) is one of the most important technologies of the future and can be defined as a technology based on the projection of virtual objects and information in a real user environment to provide additional information, in contrast to virtual reality based on the projection of real objects in a virtual environment, Here we can combine the virtual reality and the augmented together in a new system as it does not rely on the reality of a realistic graphic three-dimensional or reinforced based on the environment only [7][8][9] but the introduction of the two systems where the presentation of information and data on a real graphics system called the Mixed reality System [10]. MR is a part of visualization systems, a matter of creating a new reality by integrating realistic environment for the virtual environment that allows mixing real objects bodies producing electronic and allows the user to deal with all the objects, both types, naturally. And can be mixed to happen in the real reality, as in the supposed world of reality and thus, it is a mixture of truth and assumption includes an initial "enhanced reality" and "enhanced assumption" together[11]. Follow Figure 2.

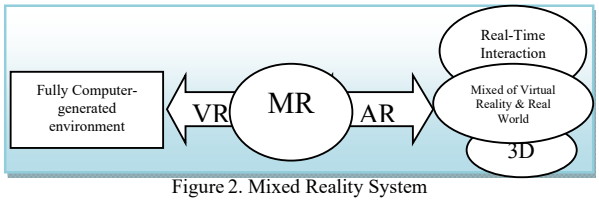

Figure 2. Mixed Reality System

For instance, Microsoft Holo [12] Lens is the first fully self-contained, holographic computer, enabling to interact with high-definition holograms in your world, follow Table1. Holo Lens embraces VR and AR to create a new reality called Mixed Reality (MR). AR overlays digital information at the top of the real world. By understanding your environment, mixed reality enables holograms to look and sound like their part of your world, follow Table2.

Table1. Microsoft HoloLens spans realities

	Augmented Reality	Mixed Reality	Virtual Reality
Augments the real world with helpful information	√	√	X
Blends holograms with your real world	X	√	X
Can transport you to a virtual world	X	√	√
Replaces the real world	X	X	√

Table2. Theoretical Analysis Between VR, AR, and MR

Feature	VR (Virtual Reality)	AR (Augmented Reality)	MR (Mixed Reality)
User presence in the experiment site	NO	YES	YES
Real-Time: User interaction with the environment at the same time	Yes/ No isolation of user	Yes often mobile devices	Yes natural interactions
See-Through Capability	No	Yes	Yes
Physically Move in the environment	No	Yes	Yes
Physical environment	Limited Physical movement	Simple & light integration	Any Room & Any Surface
Data Usage	Complete Virtual World	Overlays data	Seamless integration of real and digital

In recent years, the technology has witnessed a great leap in the field of visualization, where the devices and the presentation of programs, which led to the emergence of many glasses head, each has its own characteristics that distinguish them from others, which contains tracking-devices such as Oculus uses infrared tracking systems to the one side of the user, whereas HTC VIVE [11] uses a laser-based system in front of and behind the user, Interaction is a critical factor for VR Microsoft Dynamics offers some possibilities for interaction that are already part of the system and do not require programming on the application level , The sensors are unlike the smart cardboards of the type of Google Cardboard, which uses the sensors of the internal smartphones to determine the movements of users, the devices dedicated meters have accelerometers and sensors gyroscope.

Trends have become genuine – especially the trend in Augmented Reality wearable's such as Google's and other heads-up displays. Augmented and Virtual Reality is becoming both more accessible and more mainstream, there is an inclination of useful AR and VR wearable's to emerge [13].

3. Visualization Techniques Rates

The terms "virtual reality" and "enhanced reality" are often confused, but in reality, there are many differences between the two technologies, although they share many characteristics and advantages. Virtual reality technology either inserts or "immerses" the user in a virtual world another cross-tool is worn on a certain head or lens and isolated from the outside world. On the other hand, enhanced reality technology adds virtual elements and information to the real world, and virtual reality technology opens up unlimited virtual worlds. This technology is available in two different formats: one in independent cups and no phone to work, such as Oculus Rift figure3. The other - the most available now - is smart, like Google Cardboard figure4, but it's still hard for users to use it openly on the streets, as it's not popular with most people.

On the other hand, enhanced reality technology requires that the user can move freely in the real world, prompting Microsoft to produce independent HoloLens figure5, which includes an internal battery to continue working, and has prompted many other companies to launch other similar products without the need to other additives.

Toys and entertainment areas are the natural and primary use of virtual reality and enhanced reality, while there are aspirations to be used in more professional areas such as healthcare, architecture, education, product design, manufacturing, retail, transport, and logistics. Exploration, and military field.

Figure3 Oculus rift

Figure4 Google Cardboard

Figure5 HoloLens

In view of the Google Trends statistics, from which we can derive the level of interest in any term overtime over the past two years, virtual reality technology has been in control since July to December 2016, until the enhanced reality technology has equalized it for some time in September 2017 The VR technique returned again in December 2017, then again equated in a straight line compared to the enhanced and mixed reality technique with a different index value for each technique from January to August 2018. Figure6

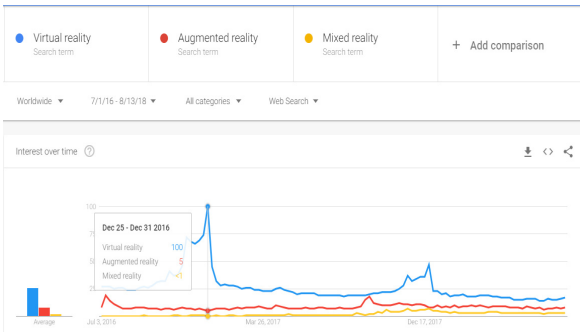

Figure6 Visualization Google Trends statistics

4. Augmented Reality in Surgery

Augmented Reality is a combination of real scene and three-dimensional graphics where this scene provides additional information to the user depending on the real scene where the user feels that the enhanced object is part of the real world and that it greatly affects the efficiency of IT, Local Features and Descriptions At present, with several assessments on random sets of images, the characteristics of the detector and prescriptions respond differently depending on the structure of the image. When the detectors and descriptions were evaluated in terms of speed and efficiency, Baiq best suited to identify the objects and descriptions used on the basis of the current object. [14], Surgeons can use the computer to perform spinal surgeries to help develop stents and nails to treat posterior column instability, through the CAS program specialized in creating a three-dimensional (imaginary) model to help the surgeon perform operations by matching the patient and the model on the screen inside But the patient must undergo a series of tests and radiation. These images are loaded onto the Cass program and create a three-dimensional image and a number of points by the surgeon where they can be imitated on a simulated model for the real patient and then the program uses these points Linking the patient's situation actually with a three-dimensional that was created to map the spine where he helps the surgeon to determine the exact position of the tools used in the surgery until the expected damage to the tissues and arteries, spinal cord and nerves as well as the length and diameter of the nail until the doctor model ensures that the transplanted exactly as planned. [15] With the technological development of the augmented reality, it allowed doctors to integrate the imaginary and potential data into diagnostics and treatment to improve work efficiency and enhance surgical training. After analyzing and studying the literature and studies from 2010 to 2016 through research in Pubmed and Scopus using the terms "augmented reality" and "surgery" Refers to the increasing interest of surgeons in improving the efficiency and effectiveness of surgical operations. However, many problems need to be addressed before implementing an enhanced reality in routine practice [16].

5. Virtual Reality and Liver Surgery

Recent years have testified to the introduction of novel techniques are known as "computer-assisted surgery" was developed. Such techniques precede This has the surgical operations and is intended to measure many factors including accuracy, safety, planning issues and while tuning up both consistency and compatibility between images of radiation, surgical instruments, and operating rooms. In this topic, scientists divided the navigation systems into three sections: (i) negative navigation, (ii) the navigational process and (iii) semi-active navigation. First, directing the surgeon to place the instruments during the operation without interfering with his work, identified as negative navigation. Second, is the pre-planning which is called the active navigational process? Thirdly, the system is allowed to operate within certain limits to perform certain tasks, and such a system is defined as semi-active navigation, which has been used since 1992 which was, to some extent, acceptable for one-dimensional imaging [17]. However, late studies and experimentations have proved that the 3D VR tool in the second phase has a great impact on supporting educational activities as well as on enhancing the abilities and skills and upgrading the intellectual level of the trainee surgeons resulting in the better design of educational materials and publishing. [18]. Consequently, more accepted results have been proven to develop and test the 3D models, the Visual Reality (VR) information retrieval (IR). IR is an application based on the exploration of physical space which guided researchers and practitioners to conclude that it is possible to deduce and extract additional values from organized groups and to proceed further in the development and selection of links between information organization and IR resulting in an interactive information visualization along with the framework of the planning of the virtual liver surgery and the eradication of tumors. Such developments combine the analysis of medical images and computer graphics, in order to simplify the planning process for the eradication of liver tumor. The focus was on surgical planning to assist surgeons in developing alternative and varied plans for surgical intervention by means of the technological advancements of the virtual reality. Consequently, the tumor eradication environment has been developed by means of simulation techniques for typical and non-standard anatomical strategies using different tools for virtual resections and quantitative measurements. The same techniques were also applied to donor liver transplantation (DLT) ending with better results. Planning tools are provided to enable surgeons to reduce the liver to the target of liver tissue [3]. For instance, the iPad-based liver development and support project was developed by the Fraunhofer Research Institute in 2013 under the title of Mavis, where the application focused on comparing the actual process with the 3D imaging data based on X-ray images. Moreover, the analysis and comparisons results have enabled surgeons to know as much information as possible before and during liver operation. To gain more insight about the preceding statements, the process determines the location of the blood vessels within the device [11].

On the other hand, some researchers tried to link the personality and its ability to draw emotional responses and reactions to the team who did not have a bad experience to identify the signs and symptoms of deterioration of the patient. This has been defined in front of them in terms of three signs of the patient's. First visual reality shaded animation, identified by mixing the

impact of measuring a number of indicators including the affective effect (EDA Electrodermal Activity) and the quantitative self-measures such as Differential Emotion Survey (DES IV) and Positive Impact and Negative Affect Schedule (PANAS). The participants' emotional states are then analyzed which has shown more excitation in males than in females. The experiments have shown that the human appearance can affect emotional reactions due to different personal perceptions and due also to the social characteristics of virtual interlocutors follow figure7. [19].

Figure7 Appearance of human appearance

For another hand, the assimilation of virtual objects is one of the phenomena depicted in figure 8 which resulted in natural and very frequent reversing of the absorption of objects in the real world. In this aspect, it relies on the blind without tactile sense responsible mainly for the strength and vibrations and reactions of the target case. Testing has resulted in the use of electrical reasons to improve user's employment of the scenario and the decreasing the needed virtual time, however resulting in finer, higher, and less reliable [20]. In this study, the creation of a hand model imitating the real hand through which it can coexist in its imaginary environment and the possibility of holding different shapes, and this through the process of hand movement depending on the fingertips (nails) The deformation of the hand tissue during the pressure of one finger on some has an effect on the virtual reality and the physical condition of the process of communication, and in the stage of implementation is simulated by (FEM and the friction) follow figure9. The point system was used to represent the smooth surface of the object and eliminate the problem derived from the polygon models. Through the experimental implementation process, it was proved that the simulation rate 50 Hz [21]

Figure8 virtual objects are one Of the phenomena

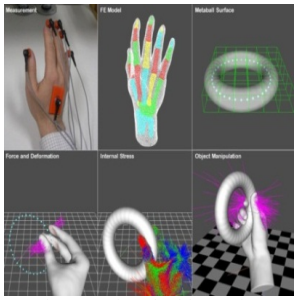

Figure9 Virtual Object using Deformable Hand

It is worth mentioning the extent of the current evolution of epidemiology and liver cancer because it has an effective effect against venous hepatitis C [22]. Therefore, the most important specialized study of the patient and preserved in the centers of the liver, so far there is no evidence based on the superiority of robotic systems on the systems The current conventional and end-point can be indicated for pediatric patients A and B and procedures for Parenchyma-sparing briers which should be better described in the Barcelona Clinic Liver Cancer Model [23][24][25] .

6. Challenges of Liver Surgical Operations

No doubt, liver operations is the very critical category to both surgeons and to patients. Consequently, more enhance training techniques and practices become necessary for training surgeons effectively prior performing liver operations especially the liver transplantation as the must step to qualify surgeons. Many challenges face surgeons in such cases, for instance, surgery after getting CT radiation of the patient are very concerned and scared from possible bleeding or cutting in one of the arteries or veins without specifying the right direction during the surgical procedure. Moreover, looking into the area of 3D graphics, and UI user views there are difficulties facing the surgeon/ trainee to track accurately the 3D model. Meanwhile, counting on the networks system and its protocols such as the TCP / IP during the training sessions may face problems due to the fact that it is common in many times that network does not work properly while still need to separate data for taking and discussions while still need to resume to go back to work once again. An additional challenge is due to the non-efficient interaction between the surgeon and patient to convert data to three-dimensional information only through the radiation of dicom before the operation or use the technique of enhanced reality during the process without interaction. In the liver transplant, surgeons need to feel and view clearly the extent of the patient's reaction when touching one Artery and veins, which presents an overwhelming challenge due to some technological problems. Consequently, continuous work should always be an important requirement to enhance real-time simulation, of liver surgery which has gained addressed success in recent years.

7. Visualization of Liver Surgical Operation Techniques

The Proposed flow chart was applied to increase the performance and develop (LSO) techniques based (MR) visualization. In this application, Two stacks are used during the process of it is designed according to the stages of the work required to pass through to increase the performance of the surgical procedures of the liver with the technique of mixed reality which is the integration of realistic environment for the virtual environment that allows mixing real objects, which allows mixing the real physical objects to enhance the positive indicators of the surgeon, by converting the CT / DICOM files into 3D models identical X+Y+Z = 1 will be intersected at the junction point to form the 3D model, and then output it with a low poly-dye to be added in the surgical training simulator before, during and after the operations, and return to the specific implementation points in the net condition=0, follow figure10. The chart is decoded using the following technique:

1. *Start Booting of the computer.*
2. *Insert / Input Dicom Files to converter app (I/O)*
3. *Check Dicom file is content X,Y,Z diminution*
4. *if(Dicom = X,Y,Z = 1) is true*
   Show/Print Dicom Files on screen (I/O)
   Else end booting software ()
5. *Check file Go to line 3*
6. *Convert Dicom to 3D_Model*
7. *if(obj file = 3diminution, X,Y,Z=1) is true*
   Export obj file high poly (I/O)
   Else Go To line 4()
8. *Edit 3D obj (Remove noise, Smoothing, Segmentation, Enhancing);*
9. *if(editing is correct =1) is true*
10. *Export obj file Low Poly (I/O)*
11. *Else Go To line 12()*
12. *Insert low poly obj in Training App to check hardware performance*
    if(Training App is smoothing = 1) is true
    Export and display Training App
    Else delay process
    Go To line 8
13. *End System*

In order to know the performance of the proposed flowchart and pseudo code, measure the performance of three devices with different specifications Table3 to identify each device through the Market Score Table4 for each component of the whole machine, The chart indicators show Figure11 an explanation of the performance of the flowchart function is approved in the denominator The first on the CPU and the VGA card and tests based on 3D based on several elements such as fogging, lighting, alpha blending, wireframe, texture, resolution, color depth, object rotation, and displacement. Standard CPU testing physical processing an also modify the simulation parameters to get different effects.

Table3 Three Devices Specification

Machine	Workstation / Fujistu	Laptop/ Dell	PC
OS	Win7 Ultimate	Win7 Ultimate	Wi7 Ultimate
Platform	64X	64X	64X
Processor	i7	i5	Core2 Duo
DirectX Ver.	10	10	10
Cores	4	2	2
Threads	8	4	------
Buss Speed	133.0 MHz	99.8 MHz	1066 MHz
Cash	8MB	3MB Smartcash	3MB L2
Date	8/8/2018	8/82018	8/8/2018
Ram	16GB	8GB	8GB
VGA Card	NVIDIA Geforce GTS 205	NVIDIA Geforce GT525M	NVIDIA Geforce 9400GT
VGA Memory	4069 MB	1023 MB	4071MB

Table4 Market Score

	CPU	2D Mark	3D Mark	Memory
Workstation / Fujistu	5452	588	771	1693
Laptop / Dell	3929	566	334	1918
PC	2172	453	130	979

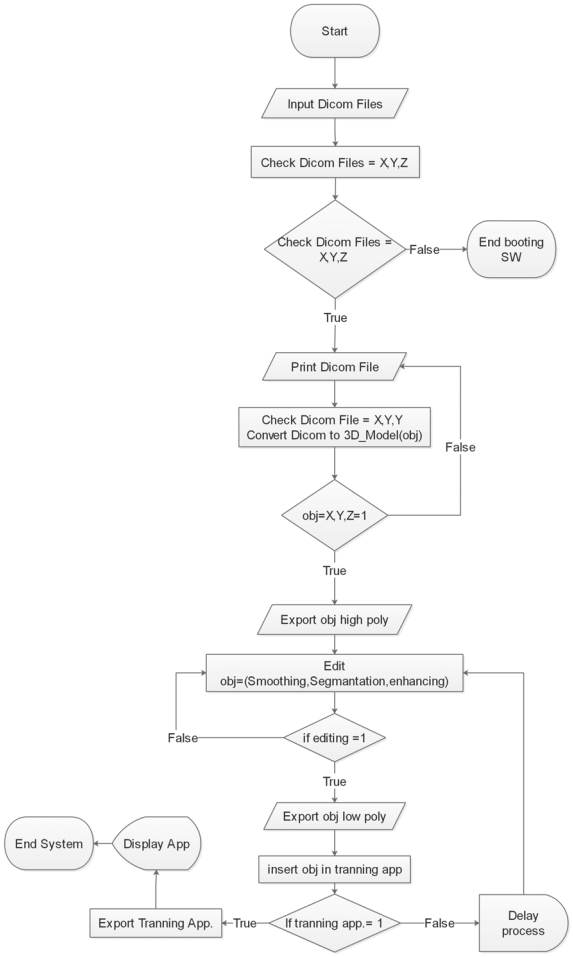

Figure10 Visualization of LSO Techniques

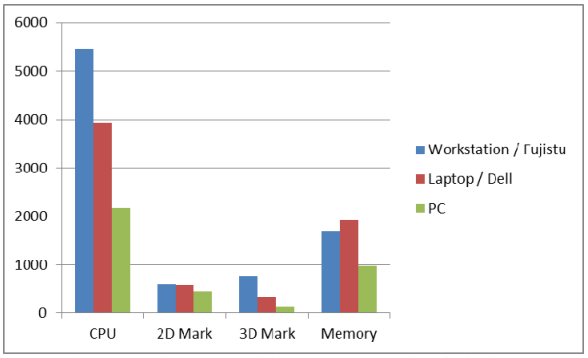

Figure11 performance of the components of each device

8. Summary and Conclusions

This paper has surveyed recent trends and developments in VR techniques including both augmented and mixed reality with more focus to their use in liver surgery. The impact of using MR to enhance visualization and to support liver surgeons with more positive indicators rather than the limited support they used to get out of patients' CT has been justified as gained value. MR is a part of visualization systems, a matter of creating a new reality by integrating a realistic environment for the virtual environment that allows mixing real objects bodies to enhance surgeon's positive indicators.

The challenges facing liver surgeons while training, prior, during and after liver operations are demonstrated from perspectives of visualization techniques. The paper has verified the added value of using MR paper.

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Biographies

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Dr. Nashaat graduated as the top of his major class1974 during his BSc in Elec. Eng. at the Military Technical College, (MTC) Cairo, Egypt. He completed Diploma in the elect. & computers eng-Ain Shams Faculty of Eng. and MSc. in computers, Faculty of Eng. Cairo-University 1980. He earned his Ph.D. in Electrical Eng., Ohio State Univ., USA, 1988. He started his academic career in MTC, where he has appointed many academic & leadership positions ending with the director of R&D Branch. He was assigned as Dean of computers, Sadat Academy, Cairo Egypt since 1998 where he was appointed many academic leadership positions: SAMs University President Nominee in 2010, University Council member, Director of R&D, Dean of the college of Port Said, Tanta, and Mansoura branches, SAMs 2000-2007. He was the Director of the Consultancy, R&D of SAMS till 2013.

Dr. Nashaat was awarded Int. and nationally including the Spanish Royal Academy Award 2011, best of AMSE Award (Association for the Advancements in Modeling and Simulation for Enterprises, Award of the distinguished Academic leadership Univ. of Texas &AM, the int. Olympic Committee Scientific National Prize of Technical Scientific Research 1995, Egypt.

He has a long experience as a top consultant for manufacturing and business firms where he supervised many granted including chairing the R&D of REEM industries, Incosteel, Infit (international joint steel industrial Egyptian German), Tax Authority, Holding Company of Irrigation Land reclamation, the sales Tax authority, Egypt.

DR Nashaat has over 120 publications in international journals and conferences while also supervised over 100 MSc and Ph.D. dissertation, and he's the author of many textbooks in areas of informatics, e-business, and health informatics. His current research interest includes business intelligence, e-business & e-gov., performance enhancement, and cyber security

He has quite an impressive record regarding int. collaborations and he's the Vice-president of the Int. Association for Advanced Modeling and Simulation for Enterprises (AMSE) (www.amse-modeling.org), Barcelona-Paris. He's also the co-founder of the Egyptian Association for Computers And Information Technology (ESIS-ACT) and the ICI committee (Texas A&M-USA, Esterhazy Academy-Hungary, Open Univ.-Malaysia, Agri-Media). He also addressed many keynotes at many events locally and internationally.

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